



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:  
Sam-Shajing SUN

Application No. 10/714,230

Filed: November 14, 2003

For: PHOTOVOLTAIC DEVICES  
BASED ON A NOVEL  
BLOCK COPOLYMER

Confirmation No.: 2469

Art Unit: 1709

Examiner: Asha J. Hall

Attorney Docket No: 036021.0001

Mail Stop Petition  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

**PETITION FOR THE ACCEPTANCE OF UNINTENTIONALLY  
DELAYED CLAIM FOR PRIORITY UNDER 37 CFR § 1.78(a)**

Dear Sir/Madam:

Applicant hereby petitions for the acceptance of the unintentionally delayed claim for priority under 37 CFR 1.78(a) for the above-referenced pending application. The above referenced pending application was filed with a priority claim referencing a provisional patent application, but this reference included a typographic error in the serial number of such reference (i.e., the incorrect reference to U.S. Provisional Patent Application Ser. No. 60/428,108, wherein the underscored 8 should have been a 6). This typographic error of a single digit was identified upon examination. At no time did Applicant intentionally delay correction of such priority claim; the entire delay was unintentional. In summary, Applicant intended to claim priority to U.S. Provisional Patent Application Ser. No. 60/426,108. With the Commissioner's acceptance, the Applicant intends to amend the above referenced application with such a correction.

This petition is accompanied by a priority claim reference to the prior-filed provisional application, U.S. Provisional Patent Application Ser. No. 60/426,108, in


Attachment A. A copy of the U.S. Provisional Patent Application Ser. No. 60/426,108 is provided in Attachment B.

The Commissioner is therefore respectfully requested to accept this correction of the priority claim of the referenced pending application. A fee of \$ 1,370 is believed to be due for this petition. Please charge the required fee to Williams Mullen Deposit Account No. 50-0766.

Date: June 19, 2007

Customer Number: 45309  
(757) 499-8800

Respectfully submitted,  
WILLIAMS MULLEN

  
\_\_\_\_\_  
M. Bruce Harper (Reg. No. 43,659)

## Attachment A

The present application claims priority from U.S. Provisional Patent Application Ser. No. 60/426,108, filed November 14, 2002, which is hereby incorporated by reference.

P1 1113515

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# THE UNITED STATES OF AMERICA

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United States Patent and Trademark Office

January 12, 2004

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OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT  
APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A  
FILING DATE.

APPLICATION NUMBER: 60/426,108

FILING DATE: November 14, 2002

RELATED PCT APPLICATION NUMBER: PCT/US03/36538



By Authority of the  
COMMISSIONER OF PATENTS AND TRADEMARKS

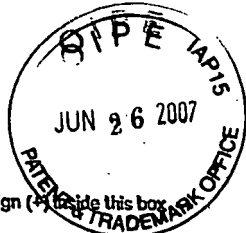
*T. Lawrence*

T. LAWRENCE  
Certifying Officer

**PRIORITY  
DOCUMENT**

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COMPLIANCE WITH RULE 17.1(a) OR (b)

11/14/02  
3c715 U.S. PTO



11-15-02

60426108 .11140A1

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SUBSTITUTE FOR PTO/SM16 (2-88)

Approved for use through 01/31/2001. OMB 0651-0037  
Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE  
OMB control number.

# PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

INVENTOR(S)					
Given Name (first and middle if any)		Family Name or Surname		Residence (City and either State or Foreign Country)	
Sam-Shajing		Sun		427 Willow Brook Way Chesapeake VA 23320	
<input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto					
TITLE OF THE INVENTION (280 characters max) A Photovoltaic Device Based on Conjugated Block Copolymers					
CORRESPONDENCE ADDRESS					
Direct all correspondence to:			Place Customer Number Bar Code Label here		
<input checked="" type="checkbox"/> Customer Number 43659					
OR			Type Customer Number here		
<input checked="" type="checkbox"/> Firm or Individual Name			M. Bruce Harper		
Address			Williams Mullen		
Address			One Columbus Center, Suite 900		
City			State	VA	ZIP 23462
Country			USA	Telephone 757-473-5357	Fax 757-473-0395
ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/> Specification Number of Pages 9			<input type="checkbox"/> Small Entity Statement		
<input checked="" type="checkbox"/> Drawing(s) Number of Sheets 3			<input type="checkbox"/> Other (specify) _____		
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)					
<input checked="" type="checkbox"/> A check or money order is enclosed to cover the filing fees			FILING FEE AMOUNT(\$)		
<input type="checkbox"/> The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 50-0766			75.00		
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
<input checked="" type="checkbox"/> No.					
<input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: _____					

Respectfully submitted,

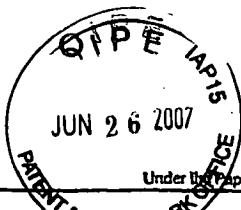
Date: 11/14/02

SIGNATURE M. Bruce Harper  
TYPED or PRINTED NAME M. Bruce Harper  
TELEPHONE 757-473.5357

REGISTRATION NO. 43659  
(if appropriate)  
Docket Number: 036021.0001

**USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT**  
This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C., 20231. DO NOT SEND FEES OR

3c973 U.S. PTO  
60/426108



60426108.111402

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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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**FEE TRANSMITTAL**

Patent fees are subject to annual revision on October 1.

These are the fees effective October 1, 1997.

Small Entity payments must be supported by a small entity statement,  
otherwise large entity fees must be paid. See forms PTO/SB/09-12.  
See 37 C.F.R. §§ 1.27 and 1.28.

TOTAL AMOUNT OF PAYMENT 75.00

**Complete If Known**

Application Number	
Filing Date	
First Named Inventor	Sun, Sam-Shajing
Examiner Name	
Group / Art Unit	
Attorney Docket No.	036021.0001

**METHOD OF PAYMENT (check one)**

1. ☐ The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number 50-0766

Deposit Account Name Williams Mullen

☒ Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17 ☐ Charge the Issue Fee Set in 37 CFR 1.18 at the Mailing of the Notice of Allowance

**2. Payment Enclosed:**Check ☒ Money Order ☐ Other ☐**FEE CALCULATION**

1. BASIC FILING FEE				Fee Description	Fee Paid
Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee	Fee		
101	760	201	380	Utility filing fee	
106	310	206	165	Design filing fee	
107	480	207	240	Plant filing fee	
108	760	208	380	Reissue filing fee	
114	150	214	75	Provisional filing fee	75.00
SUBTOTAL (1)					(\$) <u>75.00</u>

**2. EXTRA CLAIM FEES**

				Extra Claims	Fee from below	Fee Paid
Total Claims - ** =				<input checked="" type="checkbox"/> X	=	
Independent - ** =				X	=	
Claims Multiple Dependent				<input type="checkbox"/>	=	
**or number previously paid, if greater; For Reissues, see below						
Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee	Fee	Fee Description		
103	18	203	9	Claims in excess of 20		
102	78	202	39	Independent claims in excess of 3		
104	260	204	130	Multiple dependent claim, if not paid		
109	78	209	39	**Reissue independent claims over original patent		
110	18	210	9	**Reissue claims in excess of 20 and over original patent		
SUBTOTAL (2)					(\$)	

**FEE CALCULATION (continued)**

3. ADDITIONAL FEES				Fee Description	Fee Paid
Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee	Fee		
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	65	Extension for reply within first month	
116	380	216	190	Extension for reply within second month	
117	870	217	435	Extension for reply within third month	
118	1,360	218	680	Extension for reply within fourth month	
128	1,850	228	925	Extension for reply within fifth month	
119	300	219	150	Notice of appeal	
120	300	220	150	Filing a brief in support of an appeal	
121	260	221	130	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	65	Petition to revive - unavoidable	
141	1,210	241	605	Petition to revive - unintentional	
142	1,210	242	605	Utility issue fee (or reissue)	
143	430	243	215	Design issue fee	
144	680	244	290	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	760	246	380	Filing a submission after final rejection (37 CFR 1.129(a))	
149	760	249	380	For each additional invention to be examined (37 CFR 1.129(b))	
Other fee (specify)				Late filing fee/declaration surcharge	
Other fee (specify)					
*Reduced by Basic Filing Fee Paid					
SUBTOTAL (3)					(\$)

**SUBMITTED BY**

Typed or Printed Name	M. Bruce Harper	Reg. Number	43659
Signature		Deposit Account User ID	50-0766
Date	14 NOV 02		

**Complete (if applicable)**

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M. BRUCE HARPER

Typed or printed name of person mailing correspondence

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036021.0001

Title: A Photovoltaic Device Based on Conjugated Block Copolymers

Inventor: Sam-Shajing Sun

## **A Photovoltaic Device Based on Conjugated Block Copolymers**

### **BACKGROUND OF THE INVENTION**

#### **Field of the Invention:**

The present invention relates to the field of photovoltaic or opto-electronic devices. More particularly, this invention relates to cost effective, lightweight, and flexible shaped "plastic" photo detectors and "plastic" solar cells (renewable and clean energy generation), etc.

#### **Background**

Photovoltaic (PV) is a process where light is absorbed by a media and is then converted into a voltage or electric current. When light strikes certain materials, the photons in the light excite electrons in the material. In some materials, there are free electrons that are released by the interaction with the photon; the movement of that electron leaves a hole. The flow of the electron, along with the resulting holes creates electric current. Most of the PV cells used today are based on inorganic semiconductor materials such as silicon, although other materials, such as Gallium Arsenide, Cadmium Telluride, Copper Indium Diselenide are also used.

The typical silicon based solar cell uses a semiconductor pn-junction. The cell comprises semiconductor layers, one of which is n-doped (doped with atoms of excess valence electrons) and the other is p-doped (doped with atoms lacking a valence electron); their interface forms a pn-junction. The n-doped layer is characterized by



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Title: A Photovoltaic Device Based on Conjugated Block Copolymers  
Inventor: Sam-Shajing Sun

excess electrons, while the p-doped layer is characterized by holes. In other words, the n-doped layer is a donor (D) of electrons, and the p-doped layer is an acceptor (A). Initially the doped materials reach equilibrium across the pn-junction. When sunlight strikes the material, the light is absorbed in the excitation of the excess electrons, which are released and create a charge separation along the pn-junction; a transport of electrons and holes creates the electrical current that is collected by electrodes.

The high cost of manufacturing traditional inorganic photovoltaic materials and devices has led to significant research into alternative photovoltaic materials, as well as how to configure those materials within the solar cells. Additionally, improved efficiency could lower the lifetime cost and make photovoltaic devices a more commercially attractive and environmentally friendly energy alternative. One area of research is the use of organic materials to fabricate solar cells, such as using semi-conducting conjugated polymers, liquid crystalline structures, etc. Organic materials, including polymers, are relatively inexpensive, lightweight, flexible, and easily manufactured in comparison to their inorganic counterparts.

However, semi-conducting polymers work differently from inorganic semiconductors. Semi-conducting polymers are long molecules that have repeating structures and with alternating single and double carbon-carbon bonds, and are referred to as being "conjugated." The double bonds (also called  $\pi$  bonds) within conjugated polymers generate a highest occupied molecular orbital (HOMO) that is typically filled with  $\pi$  electrons, and a lowest unoccupied molecular orbital (LUMO) that is typically

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Title: A Photovoltaic Device Based on Conjugated Block Copolymers

Inventor: Sam-Shajing Sun

empty without light or other forms of excitation. The HOMO or LUMO of each double bond in a conjugated polymer backbone interact with each other and form HOMO and LUMO bands, the energy difference between the two bands is generally called band gap, or sometimes also called the "optical gap".

Most conjugated polymers appear to have a band gap that lies in the range of 1–3 eV, which makes them ideally suited for light harvesting or photovoltaic devices working in the visible light range. The photo-induced electron transfer and charge (electron-hole) separation observed in conjugated organic composites of the donors (electron-donating or p-type organic species) and acceptors (electron-withdrawing or n-type organic species) provide an alternative to traditional inorganic solar cells.

The mechanism for an organic approach to high efficiency light harvesting or photovoltaic conversion has been developed. Specifically, in organic photovoltaic materials, for instance, light generated excitons (e.g., electron-hole pairs) can typically diffuse 20 nm in their lifetime. The charges (electrons and holes) can be separated at the contact interface between the donors and acceptors, where for donor excitons, the electrons are transferred from donor's LUMO to the acceptor's LUMO and for acceptor excitons, the holes transferred from acceptor's HOMO to the donor's HOMO, provided that the corresponding energy level differences between the donor and acceptor are big enough to overcome the exciton binding energy (typically 0.5 eV). Next, and mainly due to the asymmetry of the photovoltaic cell, the electrons travel and are collected at the negative electrode, and holes travel and are collected at the positive electrodes. One of

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Title: A Photovoltaic Device Based on Conjugated Block Copolymers

Inventor: Sam-Shajing Sun

the main scientific challenges for a high efficiency organic photovoltaic device is to fabricate a nano structure where both the donor and acceptor phases have dimensions within the typical organic exciton diffusion range (about 20 nm), yet are continuous between the two electrodes.

### DESCRIPTION OF THE INVENTION

The present invention is a potentially efficient organic photovoltaic device made of a -DBA- or an analogous block copolymer system, where D is a donor derivatized conjugated polymers, oligomers, or equivalent (also referred as "conjugated donor block"), A is an acceptor derivatized conjugated polymer, oligomer, or equivalent (also referred as "conjugated acceptor block"), B is a non-conjugated (such as aliphatic) bridge unit. The said block polymer system may also be embodied in, refer to, or be represented as -ABD-, -DBAB-, -ABDB-, -BDDBA-, -BABD-, -DBABD-, -ABDBA-, etc.

The present invention comprises the structure and fabrication process of a polymer or "plastic" thin film photovoltaic device that possesses benefits of lightweight, flexible shape, cost effectiveness, and potentially very high power conversion efficiency in comparison to current commercial inorganic semi-conductor based photovoltaic devices. This "plastic" photovoltaic device has the following features:

- 1) A conjugated donor block (D) is covalently connected with a conjugated acceptor block (A) via a short non-conjugated bridge unit (B) to form a -DBA- or its analog type block copolymer chemical structure, as shown in Figure 1. Preliminary experimental

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Inventor: Sam-Shajing Sun

work has shown the -DBAB- type to be a useful embodiment. Those skilled in the art will readily see that a variety of configurations could be produced for specific applications or specifications. Preferably, the donor and acceptor blocks should be chosen, configured, or built in such a way that the band gap of both donor and acceptor phases in solid states substantially match the optical radiation energy of the intended applications or devices. This -DBA- and its analog type polymer backbone structure or "Primary Structure" can be realized via common organic design and synthesis.

2) Additionally, both the donor and acceptor conjugated block backbones may be self-assembled in a solid thin film state to form a  $\pi$ -orbital stacked or adjacent block chain closely packed structures, as shown in Figure 2, as in many conjugated polymer systems, so that the  $\pi$ -orbitals between adjacent backbones are well coupled or overlapped to each other. This may be called a "Secondary Structure".

3) Additionally, the donor and acceptor block should be sufficiently different from each other, so that in solid thin film state, donor and acceptor blocks will be able to phase separate from each other as seen in many block copolymer systems. The donor and acceptor separated phases may be self-assembled to form a columnar or "Honeycomb" shaped structures, as is the general case known in many di- or tri-block copolymer systems.

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It is known that the incompatibility between the blocks leads to the formation of many unique micro- or nano-phase separated and ordered structures, including, but not limited to, lamella, columnar, cubic centered lattice, etc., and a specific phase separated structure is determined by chemical composition, size of each block, temperature, and other factors. For instance, a recent report of MEH-PPV/Polystyrene- $C_{60}$  donor/acceptor di-block copolymer system indeed exhibited a "honeycomb" shaped nano structure.

Each donor phase column should interface with at least one acceptor column, and vice versa. The diameter of each column should be approximately within the corresponding effective exciton diffusion length of the respective donor or acceptor blocks (typically about 20 nm).

Finally, a thin layer of donor block may be coated on one side of the columnar or "Honeycomb" structure in perpendicular to the column direction in order to form a positive side of the photovoltaic device, and a thin layer of acceptor block will likewise coated on the other side of the "Honeycomb" to form a negative side of the PV device. Other forms of aligning or directing charge as is known in the art will serve as well. Finally, a conducting electrode with a work function close to, or substantially appropriate to the HOMO levels of the donor placed in contact to the donor (positive) layer side of the device will collect holes, and a conducting electrode with a work function close to, or substantially appropriate for the LUMO levels of the acceptor placed in contact to the acceptor layer (negative) side to collect electrons. At least one electrode should be

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Title: A Photovoltaic Device Based on Conjugated Block Copolymers

Inventor: Sam-Shajing Sun

transparent to the intended light radiation. This may be called "Tertiary Structure" of the said PV cell, as shown in Figure 3.

In the present invention, a -DBAB- type block copolymer system has already been synthesized and characterized recently, where D is an alkyloxy donor derivatized poly-(1,4)-phenylenevinylene (PPV), abbreviated as "RO-PPV", A is a sulfone acceptor derivatized PPV, abbreviated as "SF-PPV-I", and B is a non-conjugated aliphatic bridge unit. Preliminary electron microscopic study has revealed interesting regular nano-phase separated morphological pattern in a drop dried -DBAB- film. A donor or acceptor derivatized polythiophenes, or other similar type materials, may also be used as the conjugated blocks. A non-conjugated bridge unit provides an energy barrier between the bands of the donor and acceptor blocks in order to prevent a convenient electron-hole recombination. The bridge also makes the donor or acceptor rigid blocks less vulnerable to distortion, and more convenient to self-assemble. Conjugated  $\pi$  orbital distortion due to molecular thermal vibrations or backbone twist typically interrupts conjugation and therefore reduces charge mobility.

In summary, the backbone structure -DBA- and its analogs may be called a "Primary Structure". Since the  $\pi$  orbital overlap between rigid blocks are useful for charge mobility, this self-assembly morphology between blocks could be called a "Secondary Structure". Finally, the block copolymer "honeycomb" morphology provides

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smooth "tunnels" for charge transportation to the respective electrodes. The "honeycomb" structure may be sandwiched between a thin layer of donor film (in contact with a positive electrode), and a thin layer of acceptor film (in contact with a negative electrode) so that an efficient asymmetric polymeric photovoltaic device is thus formed. The sandwiched "honeycomb" structure can be called a "Tertiary Structure". Another advantage of this system is that the interfacial area and the phase size can be tuned via block copolymer segment size, therefore, the opto-electronic conversion efficiency can be easily optimized via materials design and synthesis.

### CLAIMS

What is claimed is:

1. A photovoltaic primary structure comprising:

- a conjugated donor block,
- a conjugated acceptor block, and
- a non-conjugated bridge covalently coupling said donor block and said acceptor block.

2. The photovoltaic primary structure as described in claim 1, wherein a second non-conjugated bridge is covalently coupled to one of either said acceptor block or said donor block, and said second non-conjugated bridge is capable of coupling to other such photovoltaic primary structures to form a repeating chain.

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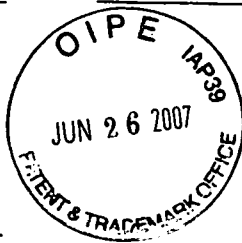
Title: A Photovoltaic Device Based on Conjugated Block Copolymers

Inventor: Sam-Shajing Sun

3. A photovoltaic secondary structure comprising a plurality of primary structures in a  $\pi$  orbital stack and closely packed morphology.
4. A photovoltaic tertiary structure comprising a plurality of secondary structures in a phase separated columnar nano-structure.
5. A photovoltaic tertiary structure as described in claim 4, further comprising a donor thin layer at a first end of such columnar nano-structure and an acceptor thin layer at an opposing second end of such columnar nano-structure, wherein said donor thin layer and said acceptor thin layer are oriented to such columnar nano-structure so as to form an asymmetric geometry.
6. A process for producing a photovoltaic primary structure comprising the steps of
  - producing a conjugated donor block,
  - producing a conjugated acceptor block, and
  - covalently coupling said donor block to said acceptor block with a non-conjugated bridge.

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Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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**DECLARATION FOR UTILITY OR  
DESIGN  
PATENT APPLICATION  
(37 CFR 1.63)**☒ Declaration  
Submitted  
With Initial  
Filing

OR

☐ Declaration  
Submitted after Initial  
Filing (surcharge  
(37 CFR 1.16 (e))  
required)

Attorney Docket Number

036021.0001

First Named Inventor

Sun, Sam-Shajing

**COMPLETE IF KNOWN**

Application Number

Filing Date

Group Art Unit

Examiner Name

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**A Photovoltaic Device Based on Conjugated Block Copolymers**

the specification of which

(Title of the Invention)

☒ is attached hereto

OR

☐ was filed on (MM/DD/YYYY)

as United States Application Number or PCT International

Application Number

and was amended on (MM/DD/YYYY)

(if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached?	
			<input type="checkbox"/>	YES	NO
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

[Page 1 of 2]

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**DECLARATION - Utility or Design Patent Application**

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

☐ Customer Number 

OR

☒ Registered practitioner(s) name/registration number listed belowPlace Customer  
Number Bar Code  
Label here

Name	Registration Number	Name	Registration Number
M. Bruce Harper	43659		

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.Direct all correspondence to: ☐ Customer Number  or Bar Code LabelOR ☒ Correspondence address below

Name	M. Bruce Harper				
Address	Williams Mullen				
Address	One Columbus Center, Suite 900				
City	Virginia	State	VA	ZIP	23462
Country	U.S.A.	Telephone	757-473-5357	Fax	757-473-0395

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
Sum-Shajing		Sun	
Inventor's Signature	Date		11/14/2002
Residence: City	Chesapeake	State	VA
		Country	23320
Post Office Address	427 Willow Brook Way		
Post Office Address			
City		State	
		ZIP	
		Country	

☐ Additional inventors are being named on the \_\_\_\_\_ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

036021.0001

Title: A Photovoltaic Device Based on Conjugated Block Copolymers

Inventor: Sam-Shajing Sun

## i) "Primary Structure"

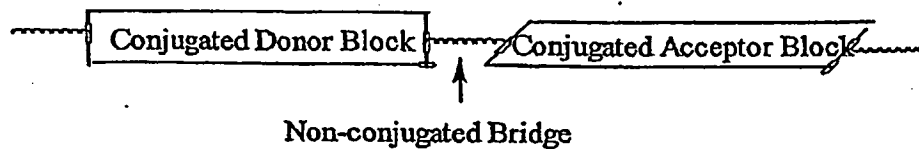


FIGURE 1

036021.0001

Title: A Photovoltaic Device Based on Conjugated Block Copolymers

Inventor: Sam-Shajing Sun

ii) "Secondary Structure"

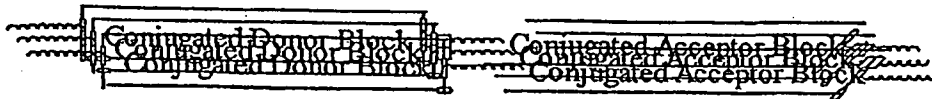


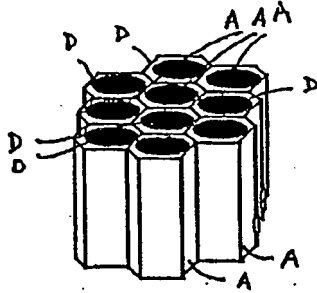
FIGURE 2

036021.0001

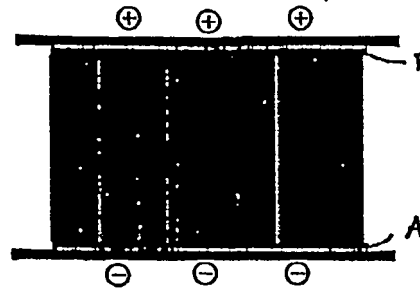
Title: A Photovoltaic Device Based on Conjugated Block Copolymers

Inventor: Sam-Shajing Sun

## iii) "Tertiary Structure"



iii-a) "Honeycomb" Morphology



iii-b) PV Device Architecture

FIGURE 3

#371314 v2

Appl. No. 10/714,230  
Amdt. Dated June 26, 2007  
Reply to Office action of March 26, 2007

**Attachment B**



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	Sam-Shajing SUN
	)	
Serial No.: 10/714,230	)	Group Art Unit: 1709
	)	
Filed: November 14, 2003	)	
	)	Examiner: Asha J. Hall
For: Photovoltaic Devices Based on a	)	
Novel Block Copolymer	)	

DECLARATION OF SAM-SHAJING SUN UNDER 37 C.F.R. 1.131

CITY OF CHESAPEAKE

COMMONWEALTH OF VIRGINIA, USA, to wit:

I, Sam-Shajing Sun do hereby declare:

1. I am the sole inventor of the patent application identified above and inventor of the subject matter described and claimed therein.
2. I am one of the co-authors of the cited publication, Fan, et al., ("Synthesis and Characterization of a Novel block Copolymer," Proceedings of Polymeric Materials: Science Engineering, v.86, 47, 2002). This document was cited against claims 9-17 of the above referenced application. The other co-authors of this cited publication were merely working under my direction within the Center for Materials Research at Norfolk State University.
3. In the same year as publication of this citation, I did cause to be prepared under my supervision the provisional patent application, U.S. App. Ser. No. 60/426,108, filed November 14, 2002. I am also the sole inventor of that provisional patent application. A utility patent application was then diligently prepared and filed, U.S. App. Ser. No. 10/714,230, which is the patent application identified above. This present application, in conjunction with a Petition for the Acceptance of Unintentionally Delayed Claim for Priority Under 37 CFR § 1.78(a) filed June 19, 2007, claims priority to that provisional patent application.

4. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application of any patent issued thereon.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct. Executed on **June 26, 2007**.

5. Further declarant sayeth not.

  
\_\_\_\_\_  
Declarant



Appl. No. 10/714,230  
Amdt. Dated June 26, 2007  
Reply to Office action of March 26, 2007

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No. : 10/714,230  
Applicant : Sam-Shajing SUN  
Filed : 11/14/2003  
TC/A.U. : 1709  
Confirmation No. : 2469  
Examiner : Hall, Asha J.  
Docket No. : 036021.0001  
For: : A Photovoltaic Device Based on Conjugated Block Copolymers



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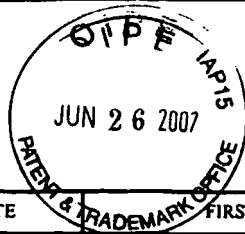
Sharon L. Hardee  
Signature of person mailing correspondence

Sharon L. Hardee  
Typed or printed name of person mailing correspondence

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/714,230	11/14/2003	Sam-Shajing Sun	036021.0001	2469

22467 7590 03/26/2007  
WILLIAMS MULLEN  
FOUNTAIN PLAZA THREE, SUITE 200  
721 LAKEFRONT COMMONS  
NEWPORT NEWS, VA 23606

EXAMINER

HALL, ASHA J

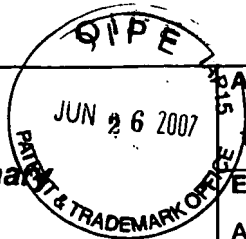
ART UNIT PAPER NUMBER

1709

SHORTENED STATUTORY PERIOD OF RESPONSE	MAIL DATE	DELIVERY MODE
3 MONTHS	03/26/2007	PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

If NO period for reply is specified above, the maximum statutory period will apply and will expire 6 MONTHS from the mailing date of this communication.

**Office Action Summary**

Application No.

10/714,230

Applicant(s)

SUN, SAM-SHAJING

Examiner

Asha Hall

Art Unit

1709

— The MAILING DATE of this communication appears on the cover sheet with the correspondence address —

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☒ Responsive to communication(s) filed on 14 November 2003.
- 2a) ☐ This action is **FINAL**.                      2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 1-21 is/are pending in the application.
- 4a) Of the above claim(s) 1-8 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 9-21 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☒ Claim(s) 1-21 are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

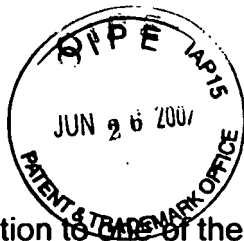
- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All    b) ☐ Some \*    c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)  | 4) <input type="checkbox"/> Interview Summary (PTO-413)<br>Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)   | 5) <input type="checkbox"/> Notice of Informal Patent Application                       |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)<br>Paper No(s)/Mail Date <u>11/14/2003 and 12/15/2003</u> . | 6) <input type="checkbox"/> Other: _____  |

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**DETAILED ACTION**

***Election/Restrictions***

1. Restriction to ~~one~~ of the following inventions is required under 35 U.S.C. 121:

Group I, Claim 1-8, drawn to a photovoltaic device based on block copolymer, classified in class 136, subclass 263.

Group II, Claim 9-21, drawn to a method of forming a photovoltaic block copolymer, classified in class 257, subclass 258.

2. The inventions are distinct, each from the other because of the following reasons:

Inventions II and I are related as process of making and product made. The inventions are distinct if either or both of the following can be shown: (1) that the process as claimed can be used to make another and materially different product or (2) that the product as claimed can be made by another and materially different process (MPEP § 806.05(f)). In the instant case the process as claimed can be used to make a materially different product. For example, the process claimed can be employed with other polymer materials (i.e. PMMA or poly(3-hexylthiophene)).

3. Because these inventions are independent or distinct for the reasons given above and there would be a serious burden on the examiner if restriction is not required because the inventions have acquired a separate status in the art in view of their different classification, restriction for examination purposes as indicated is proper. Because these inventions are independent or distinct for the reasons given above and there would be a serious burden on the examiner if restriction is not required because

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the inventions require a different field of search (see MPEP § 808.02), restriction for examination purposes as indicated is proper.

4. Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a request under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(i).

***Priority***

5. Applicant's claim for the benefit of a prior-filed application under 35 U.S.C. 119(e) or under 35 U.S.C. 120, 121, or 365(c) is acknowledged. Applicant has not complied with one or more conditions for receiving the benefit of an earlier filing date under 35U.S.C. 119 (e) as follows: The applicant claims benefit to 60/428,108 on the bibliographic data sheet. The data provided by the applicant is not consistent with the Patent and Trademark Office records.

***Claim Rejections - 35 USC § 112***

6. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter, which the applicant regards as his invention.

7. Claims 12 and 19 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

The term "easily" in claim 12 is a relative term, which renders the claim indefinite. The term "easily" is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention.

The term "enhancing" in claim 19 is a relative term, which renders the claim indefinite. The term "enhancing" is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention.

In claim 19, the phrase "photovoltaic block copolymer film" renders the claim unclear according to the context of the claim. As stated in the application, the photovoltaic block copolymer film contains donor and acceptor carrier materials, which are portrayed as being apart of the photovoltaic block copolymer film (paragraph 3 & Figure 12). The term of the photovoltaic block copolymer film has been interpreted as the device.

### ***Claim Rejections - 35 USC § 102***

8. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

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(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for a patent.

9. Claims 9-16 are rejected under 35 U.S.C. 102(a) as being anticipated by Fan et al., ("Synthesis and Characterization of a Novel Block Copolymer," Proceedings of Polymeric Materials: Science & Engineering, v.86, 47, 2002).

With regard to claim 9, Fan et al. discloses the method for forming an organic photovoltaic device, comprising of synthesizing photovoltaic block copolymer samples:

- (a) dissolving the photovoltaic block copolymer samples in a solvent (paragraph 2);
- (b) filtering the copolymer-solvent mixture (paragraph 2);
- (c) forming a film of the copolymer-solvent mixture on a pretreated glass slide/prepared surface (paragraph 2);
- (d) removing the solvent/dried overnight (paragraph 2).

With respect to claim 10, Fan et al. further shows:

- (a) individually synthesizing conjugated donor chains (Figure 1), conjugated acceptor chains (Figure 1),
- (b) non-conjugated bridge chains (Figure 1);
- (c) combining the non-conjugated bridge chains with the conjugated donor chains to form a plurality of bridge-donor-bridge units; and
- (d) combining the bridge-donor-bridge units with the conjugated acceptor chains (paragraph 5).

In regard to claim 11, Fan et al. further discloses the photovoltaic block copolymer samples synthesized by:

- (a) individually synthesizing conjugated donor chains (Figure 1),
- (b) conjugated acceptor chains and non-conjugated bridge chains (Figure 1); combining the non-conjugated bridge chains with the conjugated acceptor chains to form a plurality of bridge-acceptor-bridge units (paragraph 5);
- (c) combining the bridge-acceptor-bridge units with the conjugated donor chains (Figure 1).

With respect to claim 12, Fan et al. further discloses the solvent dried overnight in the heated vacuum oven (paragraph 2).

In regard to claim 13, Fan et al. further discloses that the copolymer-solvent solution is filtered using a filter having a pore size of about 0.2 microns (paragraph 2).

With respect to claim 14, Fan et al. further discloses that the film is formed by a method selected from the group consisting of spin coating and drop drying (paragraph 2).

In regard to claim 15, Fan et al. further discloses that the prepared surface is pre-cleaned, conducting glass/pretreated glass slides (paragraph 2).

With respect to claim 16, Fan et al. further discloses that the solvent is removed by a method selected from the group consisting of heating, vacuum exposure and a combination of heating and vacuum exposure (paragraph 2).



***Claim Rejections - 35 USC § 103***

10. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

11. Claim 17 is rejected under 35 U.S.C. 103(a) as being unpatentable over Fan et al. ("Synthesis and Characterization of a Novel Block Copolymer," Proceedings of Polymeric Materials: Science & Engineering, v.86, 47, 2002) as applied to claim 9 above, in view of Allen et al. (5,041,510) and Visscher et al., ("Construction of Multiple-Beam Optical Traps with Nanometer-Resolution Position Sensing", IEEE Journal of Selected Topics in Quantum Electronics, vol. 2, Issue 4, pages 1066-1076 (Dec.1996)).

With respect to claim 17, Fan et al. discloses the methods with respect to claim 9 above, but fails to disclose applying to the device a force selected from the group consisting of magnetic, electrical, and optical forces. Allen et al. discloses the processing of copolymer block film (col.6; lines15-24); and discloses applying a force to polymer selected from the group consisting of magnetic and electrical (col.3; lines 66-68 & col.4; lines 1-2) forces to induce alignment of mobile dipolar copolymers (col. 3; lines 66-68). Thus, it would have been obvious to one skilled in the art at the time of the invention to apply magnetic and electrical forces as taught by Allen to modify Fan et al. in order to mobilize the dipolar (charge carriers within) copolymers.

Fan et al. in view of Allen et al. fails to disclose applying an optical force to the block copolymer. However, Visscher et al. discloses the ability to manipulate molecules with forces on a molecular scale (p. 1075) and applying the use of an optical force, (also known as "optical tweezers") to generate charge carrier displacement (to move positive and negative charges) along the polymeric tracks (p. 1066). Thus, it would have been further obvious to one skilled in the art at the time of the invention to apply an optical force as taught by Visscher et al. in modified Fan et al. in order to move the charges more effectively along the conjugated chains and towards the electric field directions.

12. Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over Brabec et al., ("Origin of the Open Circuit Voltage of Plastic Solar Cells", Advanced Functional Materials, vol. 11, Issue 5, pages 374-380 (2001)) in view of Sethuraman et al. (5,972,124).

In regard to claim 18, Brabec et al. discloses:

- (a) the cleaning of entire piece of conducting glass (experimental paragraph 1; p. 379);
- (b) synthesizing a photovoltaic block copolymer from conjugated donor chains, conjugated acceptor chains and non-conjugated bridge chains (experimental paragraph 1; p. 379);
- (c) spin coating the piece of conducting glass (experimental paragraph 1; p. 379) with the photovoltaic block copolymer to form a film having a thickness of about 100nm (paragraph 2.3.1; p. 376);

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(d) vacuum depositing an electrode material on top of the film wherein the electrode material has a thickness of about 100nm (paragraph 2.3.2; p. 377), such that a positive electrode and a negative electrode are formed (paragraph 2.3.2; p. 377).

Brabec et al. fails to disclose a method of immersing a portion of conducting glass specifically in sulfuric acid. Whereas, Sethuraman et al. teaches a method of cleaning conducting glass (col. 4; lines: 25) and immersing a portion of a piece of conducting glass in a concentrated sulfuric acid cleaning solution (col.4; lines: 11-12 and lines: 25-29) to successfully clean the conducting glass without removing metals (col.4; lines: 34-35). Thus, it would have been obvious to one skilled in the art at the time of the invention to apply the cleaning steps as taught by Sethuraman et al. to the method of Brabec et al. in order to successfully clean the conducting glass without removing metals.

13. Claims 19 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Brabec et al., ("Origin of the Open Circuit Voltage of Plastic Solar Cells", Advanced Functional Materials, vol. 11, Issue 5, pages 374-380 (2001)) in view of Sethuraman et al. (5,972,124) as in claim 18 above, and in further view of Nava et al., ("Fullerene-functionalized polyesters: synthesis, characterization and incorporation in photovoltaic cells", New Journal of Chemistry, vol. 26, pages 1584-1589 (2002)).

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With respect to claims 19 and 20, modified process of Brabec et al. discloses the elements of claim 18 as discussed above, but fails to disclose forming one or more films of carrier materials. Nava et al. discloses processing of copolymer films (paragraph 2; p. 1587) and discloses forming one or more carrier films of lithium fluoride (paragraph 2; p. 1587) and poly(ethylene dioxythiophene)/polystyrene sulfuric acid (PEDOT:PSS) (paragraph 1; p. 1587) that shows clear photovoltaic behavior(paragraph 2; p. 1587). Thus, it would have been obvious to one skilled in the art at the time of the invention to include the carrier films of lithium fluoride and poly(ethylene dioxythiophene)/polystyrene sulfuric acid (PEDOT:PSS) as taught by Nava et al. to the method of Brabec et al. in order to form one or more films that shows clear photovoltaic behavior.

14. Claim 21 is rejected under 35 U.S.C. 103(a) as being unpatentable over Brabec et al., ("Origin of the Open Circuit Voltage of Plastic Solar Cells", Advanced Functional Materials, vol. 11, Issue 5, pages 374-380 (2001)) in view of Sethuraman et al. (5,972,124) as in claim 18 above, and in further view of Hummelen et al. ("Stability issues of conjugated polymer/ fullerene solar cells from a chemical viewpoint", Proceedings of SPIE vol. 4108, (2001),p76-83).

With respect to claim 21, modified steps of Brabec et al. discloses:

- (a) the forming of a film synthesized from donor chains (holes) between the positive electrode and the photovoltaic block copolymer film (paragraph 2.3.2; p.377).;

(b) and forming a film synthesized from acceptor chains (electrons) between the negative electrode the photovoltaic block copolymer film (paragraph 2.3.2; p.377).

However, modified Brabec et al. fails to disclose a photovoltaic block film with donor and acceptor chains between the positive and negative electrodes. Hummelen et al. discloses a photovoltaic block film (p.77, Figure 1b.) with synthesized donor and acceptor chains in Figure 1.b (p.77) to have the holes flow towards the positive electrode and electrons flow towards the negative electrode. Thus, it would have been obvious to one skilled in the art at the time of the invention to apply the modified steps of Brabec et al. to synthesize a photovoltaic block copolymer with donor and acceptor chains to supply a charge transfer in the photovoltaic block copolymer.

### ***Conclusion***

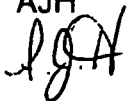
15. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Asha Hall whose telephone number is 571-272-9812. The examiner can normally be reached on Monday-Friday 7:30-5:00PM EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Alexa Neckel can be reached on 571-272-1446. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Art Unit: 1709

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

AJH



ALEXA D. NECKEL  
SUPERVISORY PATENT EXAMINER